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WEBSTER VACUUM HEATING SYSTEM
IN THE
BOSTON CITY HOSPITAL

ADMINISTRATION BUILDING
BOSTON CITY HOSPITAL

WARREN WEBSTER & CO.
CAMDEN, NEW JERSEY

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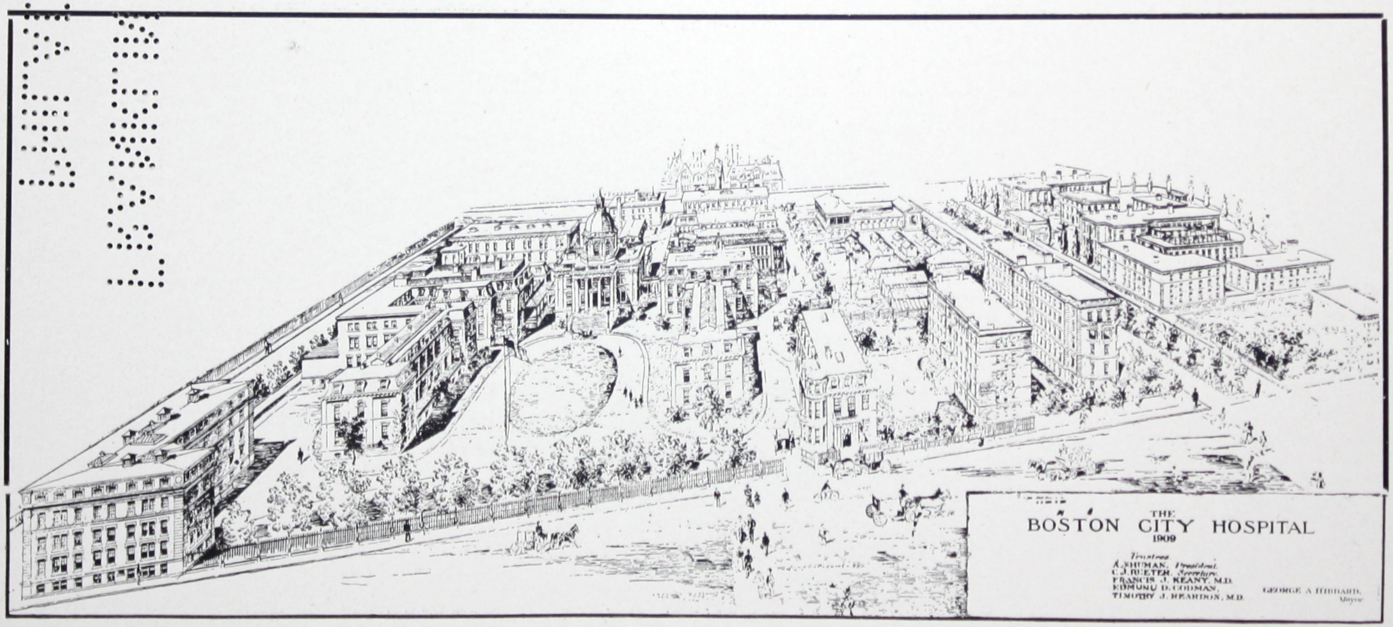

THE
BOSTON CITY HOSPITAL
1909

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Webster Vacuum Heating System in the Boston City Hospital

THE Webster heating system recently installed in twenty-six buildings of the Boston City Hospital furnishes a striking example of heating efficiency attained in the face of unusual obstacles.

In the first place, the fundamental principle of economical and efficient heating from a central station had to be violated. The central station should be near the centre of the group of buildings it is to heat. But other considerations led to locating the power house outside the grounds, so that steam had to be supplied through mains over 1000 feet in length. The extreme difficulty of getting equal circulation in all the buildings under these conditions was fully met by the Webster system.

In the second place, it was required to use for the new installation as much as possible of the old piping and radiators—a miscellaneous gathering of all sorts of types.

The third requirement was noiseless operation. How Webster methods and apparatus succeeded in spite of these difficulties forms an interesting chapter in the history of steam heating.

The hospital consists of the main hospital, situated on Harrison Avenue between East Concord Street and Northampton Street, and running completely through the block to Albany Street; the South Department, bounded by Harrison Avenue, Albany Street, Northampton Street and Massachusetts Avenue; the power plant, situated across Albany Street from the main grounds. The hospital buildings themselves have been the result of a great many years' growth, and as each building was erected, it was equipped with a steam heating system and connected with the supply and return lines from the boiler house. There was very little attempt at uniformity in the design of these heating installations, some being one-pipe and others two-pipe type. In some of the buildings the returns are at a lower level than that of the main return pipes leading back to the boiler house. Steam

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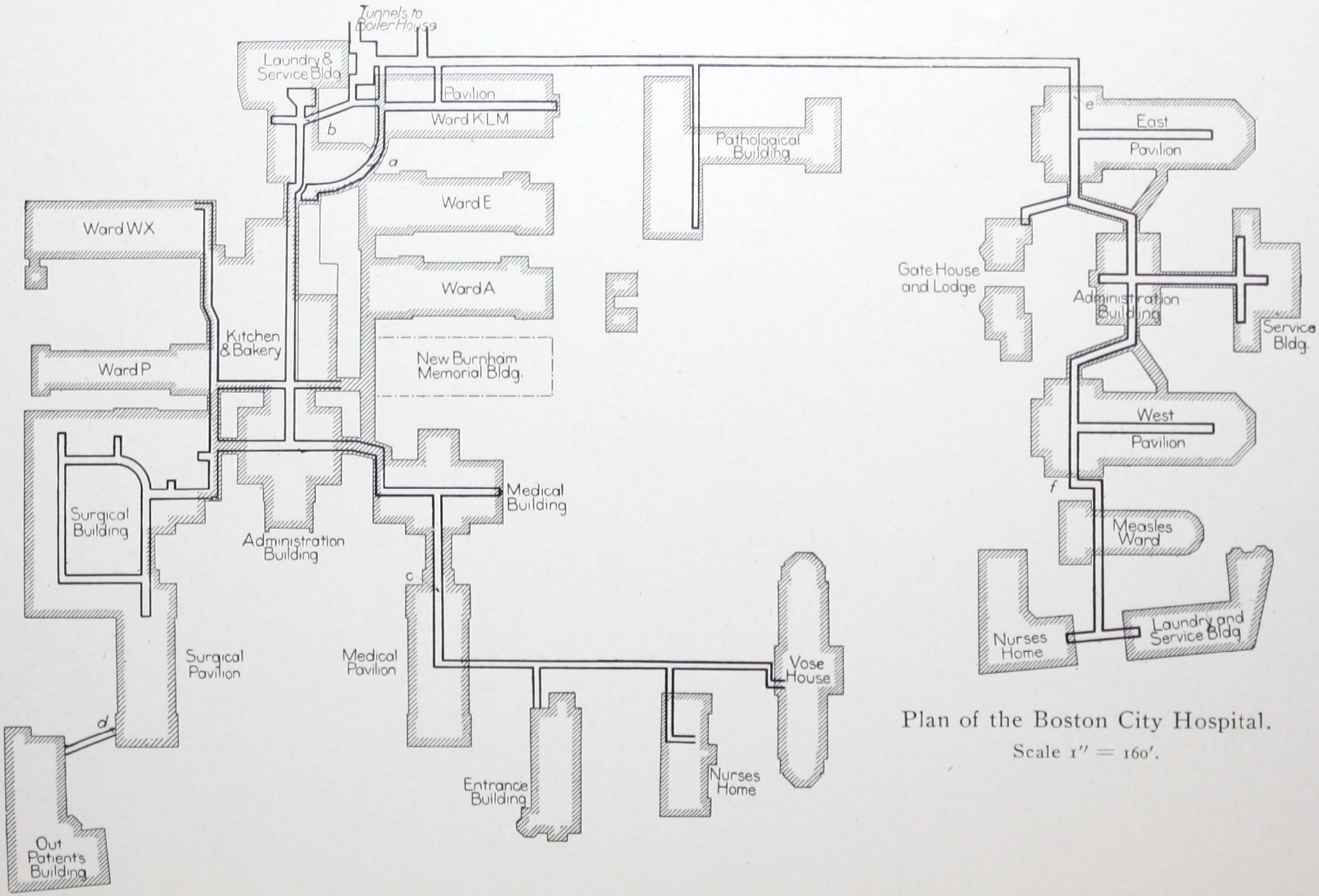


Plan of the Boston City Hospital.

Scale 1″ = 160′.

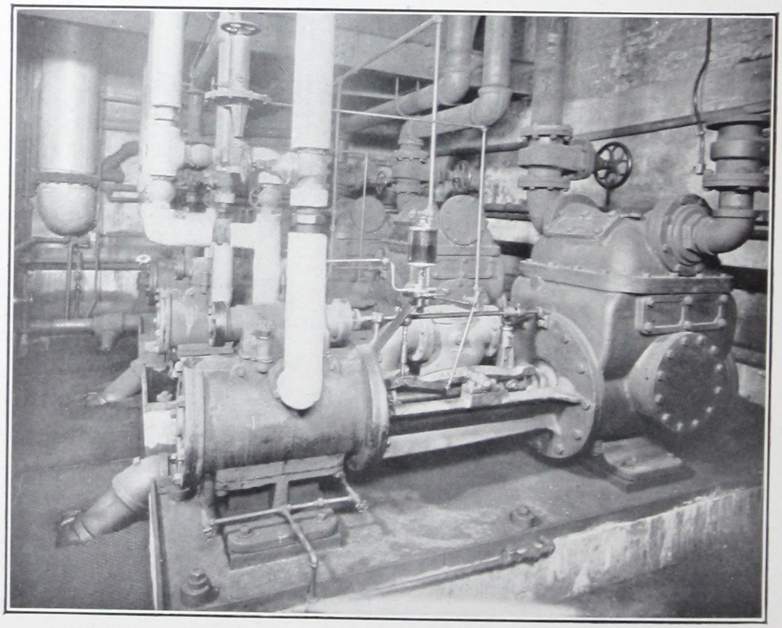
pressure was relied upon entirely to secure circulation, and no provision was made for insuring an adequate steam supply to the most remote buildings other than that afforded by increasing the pressure. In cold weather it was sometimes necessary, it is said, to put as much as ten pounds pressure on the heating system at the boiler house end in order to obtain circulation of steam through the distant buildings and also to overcome the resistance of water pockets which developed in some of the low-lying return pipes. Very often this procedure resulted in literally blowing the water out of the pipes, with consequent intermittent rushes of water to the return tank in the boiler room. At times conditions are said to have been so bad that three hours of persistent work have been necessary to obtain heat in a distant ward.

A few years ago two new buildings were added to the hospital—the Measles Ward in the South Department and the Burnham Memorial Building in the main hospital. These two additions were equipped with the Webster Vacuum System of steam heating, installed under the direction of Warren Webster & Co., Camden, N. J. Just after the completion of these two buildings the hospital authorities decided upon an entire remodelling of the heating system, and the engineering firm of Densmore & LeClear was called in to take charge of the work. On the recommendation of the engineers the seven remaining buildings of the South Department and Pavilion No. 3 and the Pathological Building in the main hospital group were equipped with the Webster system during the summer of 1908, and three Vacuum Pumps and a Webster Feed Water Heater added to the power house equipment.

The engine room equipment is very small in view of the size of the boiler plant, there being at present (1910) 1925 h.p. of boilers and but 240 k.w. in generators. Three 80 k.w. high-speed engines direct-connected to three D. C. generators, which operate on a three-wire system, provide lighting and a very small motor load. The motors are connected across the outside of the system and run on a voltage of 240, while the lighting connections are on the usual balanced three-wire scheme at 120 volts. The engines are non-condensing, as are all pumps and other steam prime movers, as the use of low pressure steam in this plant is much in excess of the supply obtainable from the various exhausts.

The coal supply for the steam plant is brought by barges to a coal tower which stands directly on the bulkhead at the side of a slip, which is about 200 feet from the rear of the boiler house. A clamshell bucket hoist of one-ton capacity conveys the coal from the barges to a hopper in the coal tower, whence a continuous bucket conveyor carries it to the main storage bunkers located between the coal tower and the boiler house. Sliding valves on the bottom of the bunkers permit the coal to slide into a trench below the ground level, where the same bucket conveyor on its return trip takes the fuel up again over the top of the bunker into a boiler room, where it is tripped into three fifteen-ton weighing hoppers which are supported on girders directly over the centre of the firing aisle and from which circular chutes feed the coal into cars running on tracks in the middle of the aisle. These cars are moved up and down in front of the boilers and the coal fired by hand direct.

Underneath the car tracks is the trench in which runs the same bucket elevator which is used for conveying the coal. This is used to convey the ashes to a pocket in the coal tower, whence they are hauled away in carts. An interesting feature of this installation is that one conveyor is arranged to handle both coal and ashes, the former being handled twice in the course of its movement from the coal tower to the boiler room, and this arrangement should work an economy in the cost of handling.



Vacuum Pumps with Webster Vacuum Governors.

The elevator is operated by a steam engine, as is also the bucket hoist.

There are three single 12″ x 18″ x 18″ brass-fitted vacuum pumps, each provided with a Webster vacuum governor and a force feed lubricator. Two of these handle the returns from the entire heating system. The pump exhausts are connected with a 4-inch Webster oil separator in order that the steam may be used satisfactorily for heating. The various pumps and engines which exhaust into the heating system in the various buildings are also provided with Webster oil separators and drips, and the main exhaust pipe near the header, as well as the separator drips, is provided with Webster grease traps. Four pumps are used to feed the boilers—one vertical marine 10″ x 6″ x 10″, two simplex 5½″ x 9″ x 12″, and one duplex 12″ x 7″ x 12″. The feed water heater is a Webster 1500 h.p. class ED horizontal heater, especially designed for this installation. The hospital is served by five elevators in various buildings, each having its separate pump, which exhausts into the heating system as already described.

Webster Class ED Horizontal Feed Water Heater.

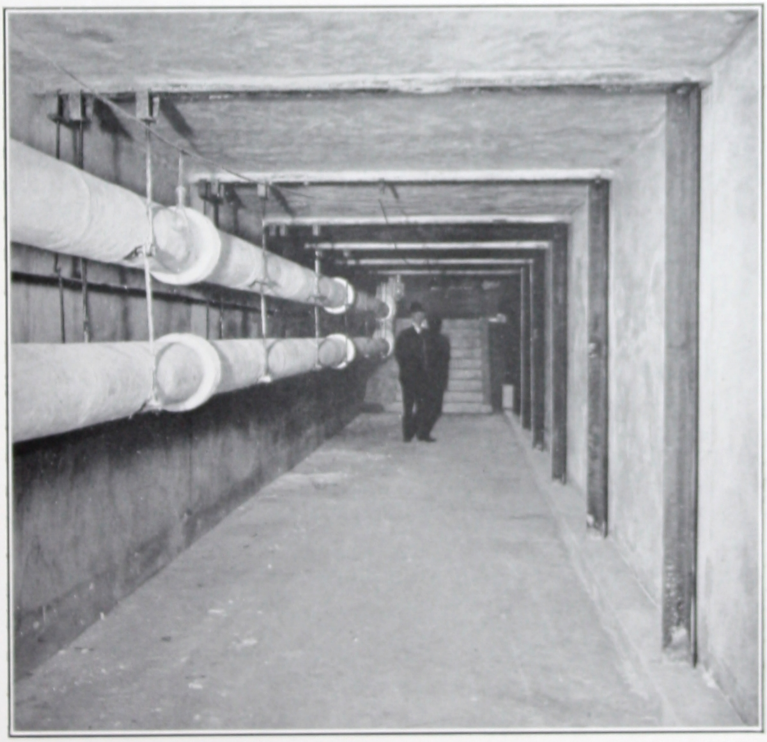
During the summer of 1909 the extension of the Webster vacuum system to include the remainder of the hospital, except the laundry and service building of the main hospital group, was completed. A new tunnel was constructed under Albany Street and additional pipes laid therein in order to relieve congestion in the old tunnel, which was so crowded with pipes that it was impossible to inspect them or to make repairs without great difficulty.

At the same time that the overhauling of the heating system was completed the six oldest boilers, which had been in service sixteen years, were replaced by four 350 h.p. B. & W. water-tube boilers, which increased the capacity of the station by 540 h.p. Four of the old boilers—one 150 h.p. and three 125 h.p. Hodge return tubular boilers—were retained, so that the present total nominal capacity of the station is 1925 h.p. The units are arranged on opposite sides of the main firing aisle, the four water-tube boilers being on one side and the old return tubulars opposite them. The old chimney, which was inadequate even for the original equipment, was torn down and replaced by a new Kellogg radial brick stack 200 feet in height and 8 feet inside diameter at the top. New shaking grates, flues and piping for the water-tube boilers were also installed at this time.

Under the present conditions there are three distinct steam pressures carried for various purposes. The high pressure, or boiler steam, is maintained at about 100 pounds and serves the various engines and pumps. An intermediate pressure of from 25 to 30 pounds, known as service steam, is used for the hot water heaters, steam tables, laundry service and various other uses about the hospital. The amount of steam used in washing is a very considerable item, as there are as many as 100,000 pieces laundered monthly. The service steam system is supplied from the main steam header through reducing valves. For the heating system the pressure varies between two and three pounds above atmosphere at the supply end, while the average vacuum at the pumps is about 10 inches.

The main steam header supplied by the boilers is 12 inches in diameter. High pressure steam for all purposes is conveyed to the hospital through three 6-inch mains, one in the old tunnel under Albany Street and the other two in the new tunnel parallel to it. Of the latter, one is designed to supply the needs of the main hospital, while the other runs directly to the South Department, replacing an 8-inch line in the old tunnel, which was known as the "summer main." This main has been disconnected, but could be used in case of emergency. The other boiler main in the old tunnel is connected in parallel with the new mains and can be used to replace either of the latter. At the mouth of the old tunnel, connection is made from the new South Department service steam return main, which replaced a similar return line, to the service steam return from the main hospital to the power house, and the returns from Pavilion No. 3 and the Pathological Building tie into this main. The main low pressure steam line from the power house is a 16-inch pipe running in the old tunnel, with branches leading to the main hospital and the South Department—12-inch to the South Department and two branches, 8-inch and 10-inch respectively, to the main hospital. The service line to the hospital laundry is a 4½-inch pipe laid in the old tunnel, reducing to 3½-inch at the laundry and connected in parallel with a 5-inch boiler steam line through a reducing valve.

The low pressure returns from the main hospital are gath-

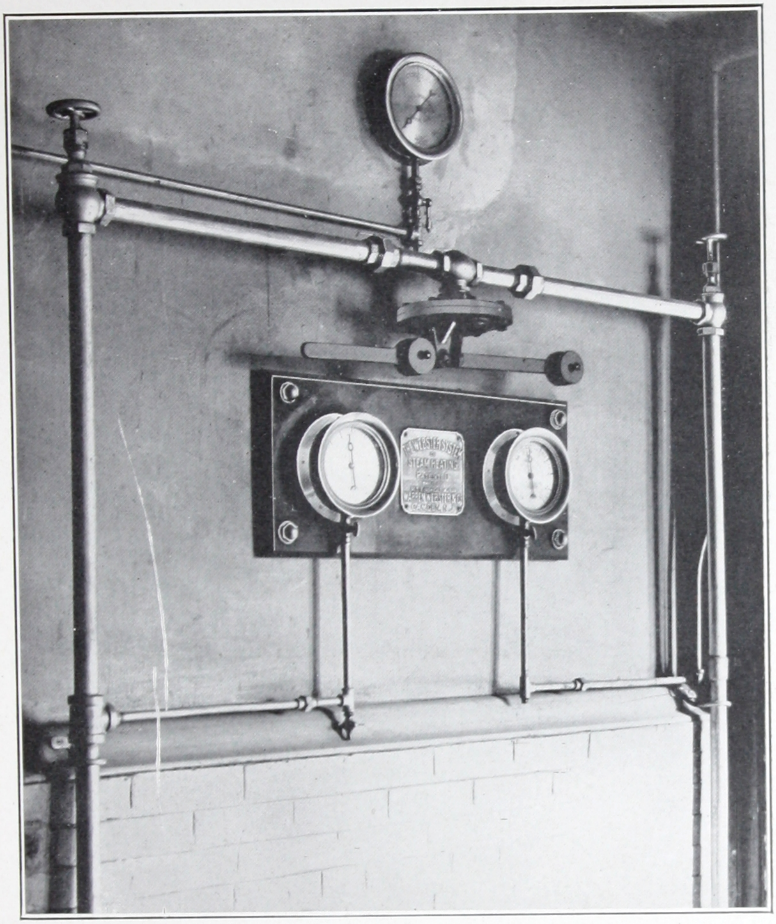


Tunnel Under Albany Street.

ered into a 7-inch return line in the old tunnel, and the South Department is served by a 5-inch brass low-pressure return main, also installed in the old tunnel. All the steam and return lines for the main hospital are carried in tunnel passages up through the centre of the grounds, with branches taken off at various points to supply the buildings; finally divided into two main branches running—one to the Surgical Building and Pavilion and the Surgical Out-patients' Building, and the other to the Medical Building and Pavilion, the Nurses' Home, the Entrance Building and the Vose House. The pipe lines supplying the South Department run in a tunnel parallel to Albany Street, and branches from these mains supply Pavilion No. 3 and the Pathological Building, which are situated in the corner of the main hospital grounds opposite the South Department. These mains cross under Northampton Street and then run at right-angles towards Harrison Avenue, with branches to all the buildings of the South Department.

The main exhaust header is connected at one end to the feed water heater, and there is also provided a free exhaust line running through the roof. The heating return mains from the South Department and from the main hospital connect with each of the three vacuum pumps and are also cross-connected so that any pump may be used on either main. There is a high-pressure drip receiver in the boiler house to which the drip returns are piped, and all clean pump room drips also run into this receiver. An automatically governed duplex sump pump handles the discharge from a sump tank which receives the pump drips and draw-offs from the high-pressure receiver, drip returns, etc.

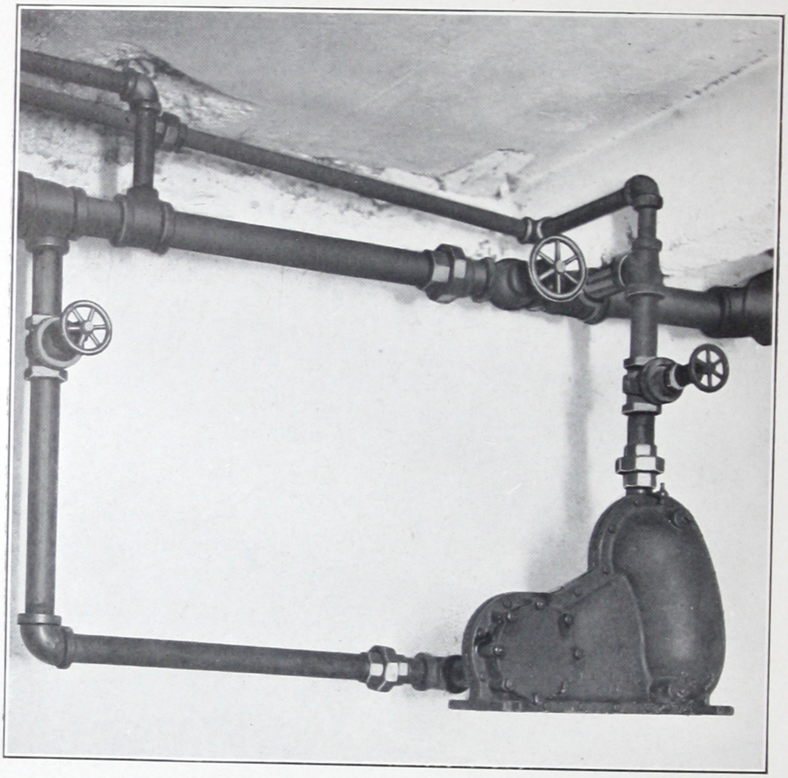
The Webster "Hylo" vacuum heating system as installed in the hospital is provided with a regulating apparatus for automatically maintaining the desired degree of vacuum in each of the scattered buildings. This is accomplished by means of the Webster "Hylo" apparatus, which controls the vacuum, and may be set to give any building any desired amount of vacuum up to that of the main line to the pumps. Each group of radiators comprising the equipment of any building is in this way furnished with an apparatus by means of which the freedom of circulation of steam may be readily determined by the vacuum gauges on either side of the "Hylo" diaphragm vacuum controller. These are located in the building corridors wherever possible so as to be easily accessible for examination. The accompanying



Webster "Hylo" Vacuum Controller.

illustrations show an example of such an installation and likewise a "Hylo" trap, which discharges the condensation of a set of radiators to the return mains. The vacuum controller through which the air is discharged appears in the centre of the picture. The vertical pipes on each side lead to the inlet and discharge side of the trap, which is located in the basement below the controller. The vacuum line from the pumps connects with the discharge side of the trap and to one side of the controller, while the other side of the latter and the inlet side of the trap connect with the building returns. Thus there is a high vacuum on the discharge side of the trap and a low vacuum, as maintained by the controller, on the inlet side.

The traps may be placed at some distance from the controlling apparatus. Aside from the ease with which the circulation can be guaranteed by means of this device, in this particular installation, with its many old buildings, it was found to render a valuable service in detecting plugged-up pipes in different parts of the old system. When circulation seemed impeded, it was possible by adjusting the controller to run the suction up to the full vacuum of the pumps, and if steam still failed to flow in a group of radiators, it was evidence of an obstruction in that particular line. All radiating units are equipped with Webster water-seal motors on the discharge end. These automatic traps serve to discharge water and air from the radiators into the return lines, but do not permit the passage of any appreciable volume of steam. In addition to the direct radiators, the fan coils and a good



Webster "Hylo" Trap.*

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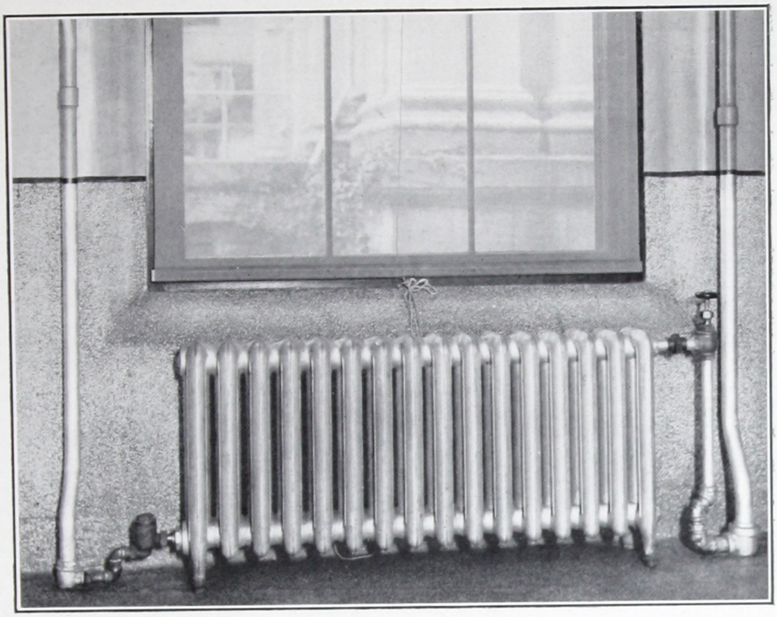
*The small pipes at the top lead to and from the controller.



Radiator, Showing Webster Water-seal Motor.

many of the vent coil returns and the drips from the heating pipes in all the buildings provided with the vacuum system, were equipped with water-seal motors on the discharge end. In all, approximately 1700 of these motors have been installed throughout the institution in sizes varying from ½ to ¾ inch. A dirt pocket is provided in connection with each Webster water-seal motor on indirect radiators made up of 1¼-inch pipe about 8 inches long, capped at the bottom and screwed into a tee looking down, the union of the flange being screwed into the run of the tee. These dirt pockets, however, were not installed in the cases of water-seal motors on the direct radiators or those protected by Webster dirt strainers. The latter are provided for the fan heaters and all drip points in the mains only. Each group of indirect radiators has a separate water-seal motor located outside the casing in order to make it easily accessible. Webster oil separators are provided for each of the elevator pumps, for the fan engines and for the refrigerating engine in the Pathological Building. Three-quarter inch Webster grease traps have been installed in connection with the oil separators, and one 1¼-inch Webster grease trap is located on the tank drip under the engine room. There are hand valves, as well as the water-seal motors, on all the drips from the mains and run-outs. In several cases there is a rise on the returns, usually in the tunnels where each building return joins the main return, and lifting pockets are installed at all these points. The radiators on the Webster vacuum system are fairly well divided between direct and indirect, some of the latter being on fan systems, while others are on gravity systems of natural ventilation.

In several of the buildings vapor economizers, made up of 1½-inch pipe, are inserted in the main returns from the fan stacks. These are placed in the cold-air chambers. The only building which has not been equipped with the Webster vacuum system of steam heating is the laundry and service building of the main hospital. This is an old one-pipe system and it was decided to continue its use, particularly as the character of the building insured a plentiful supply of heat aside from that provided by the radiators themselves. As already mentioned, a great deal of steam is used for the various washing processes as well as for cooking, and on this account the heating system in this building is of secondary importance.

The Surgical Out-patients' Building was originally provided with two types of heating—fifty-four of the direct radiators being on a one-pipe system and two direct radiators and all of the indirect radiators on a two-pipe system. These were all changed over to the Webster Vacuum system and return lines installed in the case of the one-pipe radiators. The return connections from the indirect radiators, which formerly were inside the casing, were changed to outside, and the water-seal motors, which were applied to the connections to the returns, were in every case placed outside where they could be easily inspected. In quite a number of cases it was found possible to utilize the old air valve lines of the one-pipe system as returns for the new two-pipe system. In general, any air lines ½ inch or over were made use of in this manner, although in some cases it was even possible to use as small as ⅜-inch brass pipe for this purpose, thus making a considerable saving. In the Administration Building of the South Department, it was found possible to use a considerable amount of this small brass pipe which would otherwise have had to be scrapped.

In the Surgical Building of the main hospital there was originally a two-pipe system connected to radiators partly for direct and partly for indirect radiation. The direct radiators are all concealed behind iron screens and placed under the windows and the piping is mostly concealed or built in. There are two sets of fan stacks, one for the amphitheatre and the other serving the rest of the building. Lifting pockets had to be installed for the returns from the lower part of this building and from the Out-patients' Building, as they were on a considerably lower level than the main heating return line of the main hospital.

The original system in the Vose House was of the one-pipe variety. In order to avoid the necessity of cutting through the concrete floors for an entirely new set of return risers, as well as to make use of as much as possible of the old piping, one half the one-pipe risers were converted into return lines, the remainder being retained as risers for the new system. By connecting nearly twice as many radiators onto each riser, it was possible to transform the entire equipment into a vacuum system with the addition of scarcely any new piping. Despite the greater number of radiators to each riser, no trouble has been experienced with the made-over heating system.

The success of the steam heating system in the City Hospital is particularly noteworthy in view of the extreme conditions which it had to meet. The operation of any kind of mechanical apparatus in hospitals, to be satisfactory, must first of all be quiet in operation. A second difficult condition which the steam heating system of this institution had to meet and overcome was the extreme lengths of pipe which were necessary to connect all the buildings of the hospital with the power plant. The longest heating main is that which supplies the South Department. This pipe is over 1100 feet in length from the boiler house to its end at the Harrison Avenue side of the South Department. In the main hospital group, the Surgical Out-patients' Building is reached by approximately 900 feet of piping, while close to 1000 feet is required for the heating mains to the Vose House and Nurses' Home.

The fact that it would have been inadvisable to locate the boiler house in the centre of the grounds dictated this feature of the design. The number and variety of heating units served, as well as the lack of uniformity in the grouping of these units, formed the third difficulty which a successful heating system had to face.

It has been a matter of extreme interest to every one connected with the hospital to ascertain the extent to which the heating system here described has fulfilled these exacting requirements. One of the most noticeable benefits derived from the change to the Webster vacuum system has been the elimination of water hammer and similar noises so often associated with steam heating. This was one of the greatest causes of annoyance with the old outfit, and the quiet heating obtained with the vacuum system is one of the most gratifying features.

The unusual length of piping necessary to reach the outlying buildings has proven not at all detrimental to the proper operation of the Webster system. The supply lines are in all cases carefully dripped to the vacuum returns and all low places provided with lifting pockets, traps or other devices in order to insure thorough removal of condensation. The "Hylo" vacuum controlling equipment equalizes the distribution of steam throughout the entire heating plant and insures a lower initial pressure and lower vacuum at the power house than would otherwise be necessary.

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